

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
7 June 2001 (07.06.2001)

PCT

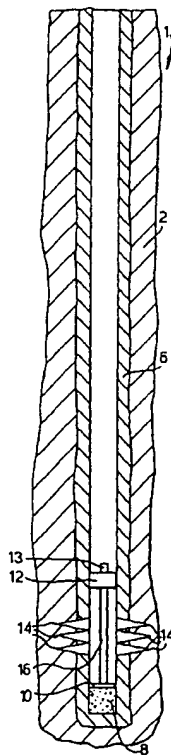
(10) International Publication Number
WO 01/40617 A1

- (51) International Patent Classification: **E21B 33/124**, 43/14, 43/26 (72) Inventors: **BRAITHWAITE, Stephen, Richard**; Volmerlaan 8, NL-2288 GD Rijswijk (NL). **HEIJNEN, Wilhelmus, Hubertus**; Grote Hout of Koningsweg 49, NL-1951 GN Velsen (NL).
- (21) International Application Number: PCT/EP00/11998
- (22) International Filing Date: 28 November 2000 (28.11.2000) (81) Designated State (national): NO.
- (25) Filing Language: English (84) Designated States (regional): European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).
- (26) Publication Language: English
- (30) Priority Data: 99204023.8 29 November 1999 (29.11.1999) EP Published: — With international search report.
- (71) Applicant: **SHELL INTERNATIONALE RESEARCH MAATSCHAPPIJ B.V.** [NL/NL]; Carel van Bylandtlaan 30, NL-2596 HR The Hague (NL). For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: CREATING MULTIPLE FRACTURES IN AN EARTH FORMATION



WO 01/40617 A1



(57) Abstract: A method of creating multiple fractures in an earth formation surrounding a wellbore formed in the earth formation, the method comprising sealing a first section of the wellbore from the remainder of the wellbore by arranging a primary seal assembly in the wellbore, the first section containing a first body of fluid and being located between the primary seal assembly and the wellbore bottom, pressurising the first body of fluid so as to fracture the earth formation surrounding the first section, sealing a second section of the wellbore from the remainder of the wellbore by arranging a secondary seal assembly in the wellbore uphole the primary seal assembly, the second section containing a second body of fluid and being located between the secondary seal assembly and the primary seal assembly, supporting the primary seal assembly by a first support member extending between the primary seal assembly and the wellbore bottom, and pressurising the second body of fluid so as to fracture the earth formation surrounding the second wellbore section.

CREATING MULTIPLE FRACTURES IN AN EARTH FORMATION

The present invention relates to a method of creating multiple fractures in an earth formation surrounding a wellbore formed in the earth formation. It is general practice to create such fractures to stimulate hydrocarbon fluid production from the earth formation, or to provide a flow path for injection fluid. In many instances the formation is to be fractured at different depth levels along the wellbore, for example in case hydrocarbon fluid is to be produced from earth layers at different along hole distances. A normal procedure for creating fractures is to perforate the wellbore casing at the required depth and to pump fracturing fluid into the formation via the casing perforations. Thereafter the fractures are subjected to treatment process, for example by pumping an acid into the fractures, or pumping proppant material into the fractures in order to prevent closure of the fractures. A problem arises in case after treatment of the fractures created at a first location, fracturing fluid is pumped into the wellbore in order to create fractures at a second location since any penetration of fracturing fluid into the fractures at the first location will negatively affect the treatment results of such fractures.

Accordingly it is an object of the invention to provide a method of creating multiple fractures in an earth formation surrounding a wellbore, whereby earlier created fractures are not negatively affected by the creation of later fractures.

In accordance with the invention there is provided a method of creating multiple fractures in an earth

formation surrounding a wellbore formed in the earth formation, the method comprising

- sealing a first section of the wellbore from the remainder of the wellbore by arranging a primary seal assembly in the wellbore, the first section containing a first body of fluid and being located between the primary seal assembly and the wellbore bottom;
- pressurising the first body of fluid so as to fracture the earth formation surrounding the first section;
- sealing a second section of the wellbore from the remainder of the wellbore by arranging a secondary seal assembly in the wellbore uphole the primary seal assembly, the second section containing a second body of fluid and being located between the secondary seal assembly and the primary seal assembly;
- supporting the primary seal assembly by a first support member extending between the primary seal assembly and the wellbore bottom; and
- pressurising the second body of fluid so as to fracture the earth formation surrounding the second wellbore section.

By supporting the primary seal assembly relative to the wellbore bottom it is achieved that the second wellbore section is adequately sealed from the fractures created around the first wellbore section.

The invention will be described further in more detail and by way of example with reference to the accompanying drawings in which

Fig. 1 schematically shows a wellbore formed in an earth formation during a first stage of operation of an embodiment of the method of the invention;

Fig. 2 shows the wellbore of Fig. 1 during a second stage of operation;

Fig. 3 shows the wellbore of Fig. 1 during a third stage of operation;

Fig. 4 schematically shows a running tool for running a seal assembly used in the embodiment of Fig. 1; and

5 Fig. 5A schematically shows a retrieving tool in a first mode of operation, for retrieving the seal assembly of Fig. 4; and

Fig. 5B schematically shows the retrieving tool of Fig. 5A in a second mode of operation.

10 Referring to Fig. 1 there is shown a wellbore 1 formed in an earth formation 2 during a first stage of operation, the wellbore being provided with a tubular casing 4 cemented in the wellbore 1 by a layer of cement 6. A body of gravel particles 8 covered by a
15 reaction plate 10 is arranged in the lower end part of the wellbore 1. A primary seal assembly 12 is sealingly arranged in the casing 4 at a selected level above the reaction plate 10, the primary seal assembly being provided with a running/retrieving device 13 and being
20 supported by a first support strut 16 extending between the primary seal assembly 12 and the reaction plate 10. A set of primary fractures 14 is formed in the earth formation at a level between the reaction plate 10 and the primary seal assembly 12.

25 In Fig. 2 is shown the wellbore 1 during a second stage of operation, whereby a secondary seal assembly 20 is sealingly arranged in the casing 4 at a selected level above the primary seal assembly 12. The secondary seal assembly 20 is provided with a running/retrieving
30 device 24 and is supported by a second support strut 26 extending between the secondary seal assembly 20 and the primary seal assembly 12, the second support strut 26 at the lower end thereof being provided with a protector cap 27 fitting over the running/retrieving device 13. A
35 set of secondary fractures 28 is formed in the earth

formation at a level between the primary seal assembly 12 and the secondary seal assembly 20.

5 In Fig. 3 is shown the wellbore 1 during a third stage of operation, whereby a tertiary seal assembly 30 is sealingly arranged in the casing 4 at a selected level above the secondary seal assembly 20. The tertiary seal assembly 30 is provided with a running/retrieving device 34 and is supported by a third support strut 36 extending between the tertiary seal assembly 30 and the secondary seal assembly 20, the third support strut 36 at the lower end thereof being provided with a protector cap 37 fitting over the running/retrieving device 24. A set of tertiary fractures 38 is formed in the earth formation at a level between the secondary seal assembly 20 and the tertiary seal assembly 30.

15 In Fig. 4 is shown in more detail the primary seal assembly 12 with a running tool 50 attached thereto, the running tool and primary seal assembly having longitudinal axis of symmetry 52. The primary seal assembly 12 includes a cup-shaped elastomeric seal 54 biased between a body 56 and a plate 58. The running/retrieving device 13 includes a bolt 60 screwed into a threaded bore 64 of the body 56, the bolt 60 having a shoulder 61 biasing the circular plate 58 against the elastomeric seal 54. The bolt 60 has a hexagonal head 62. A spacer 66 of selected thickness is arranged between the bolt 60 and the bottom of the bore 64. The hexagonal head 62 is provided with an annular groove 68. The running tool 50 includes a hexagonal socket 70 having radially movable fingers 70a provided with dogs 71 fitting into the groove 68, and a shaft 72 fitting into the socket 70 and being connected thereto by a threaded connection 73 and a plurality of shear pins 74. The shaft 72 has a tapered end part 76, and the fingers have inwardly extending socket tapers 78.

The first support strut 16 is fixedly connected to the body 56.

The secondary and tertiary seal assemblies 20, 30 are similar to the primary seal assembly 12.

5 Referring to Figs. 5A, 5B there is shown in more detail the primary seal assembly 12 together with a retrieving tool 80, the retrieving tool 80 and primary seal assembly 12 having longitudinal axis of symmetry 82. The retrieving tool 80 includes a shaft 84 provided with
10 a shaft extension 85 having a bore 86 into which a spool 88 extends, the spool 88 having an annular lock surface 89 and being slideable in longitudinal direction relative to the shaft extension 85 between an extended position (shown in Fig. 5A) and a retracted position
15 (shown in Fig. 5B). The retrieving tool 80 furthermore includes a plurality of fingers 90 (only one of which is shown) rotatable about pins 92, each finger 90 being provided with a dog 91 fitting into the groove 68. The fingers 90 are biased to a radially inward rotational
20 position by spring elements 93. The location of each pin 92 relative to the spool 88 is such that the annular lock surface 89 allows radially outward hinging of the fingers 90 when the spool 88 is in the extended position, and prevents radially outward hinging of the fingers 90
25 when the spool 88 is in the retracted position. The spool 88 is provided with a nose section 94 extending into a bore 96 of the spool 88 and being slideable in longitudinal direction relative to the spool 88. A first compression spring 98 is arranged in the bore 96, the
30 spring 98 biasing the nose section 94 in the direction of the hexagonal head 69 of the seal assembly 12. A second compression spring 100 is arranged in the bore 86, the spring 100 biasing the spool 88 biasing each finger to a radially inward position thereof.

During normal operation the wellbore 1 is drilled and the casing 4 is cemented in the wellbore 1. The casing 4 is then perforated and fracturing fluid is pumped into the wellbore so as to create the set of primary fractures 14, whereafter propant is pumped into the fractures 14.

The body of gravel particles 8 is then formed from residual propant deliberately left in the wellbore 1. Next the primary seal assembly 12 with the first support strut 16 and reaction plate 10 connected thereto is lowered into the casing 4 until the reaction plate 10 contacts the body of gravel particles 8. The primary seal assembly is then activated (as described hereinafter) so as to seal against the inner surface of the casing 4

In a next step fracturing fluid is pumped into the wellbore so as to create the set of secondary fractures 28, whereafter propant is pumped into the fractures 28. During fracturing the first support strut 16 prevents the primary seal assembly 12 from being laterally displaced. The secondary seal assembly 20 with the second support strut 26 connected thereto is then lowered into the casing 4 until the second support strut contacts the primary seal assembly 20 whereby the protector cap 27 fits over the running/retrieving device 13. Next, the secondary seal assembly is activated (as described hereinafter) so as to seal against the inner surface of the casing 4.

In a further step fracturing fluid is pumped into the wellbore so as to create the set of tertiary fractures 38, whereafter propant is pumped into the fractures 38. During fracturing the second support strut 26 prevents the secondary seal assembly 20 from being laterally displaced. The tertiary seal assembly 30 with the third support strut 36 connected thereto is then lowered into the casing 4 until the third support strut

contacts the secondary seal assembly 20 whereby the protector cap 37 fits over the running/retrieving device 24. The tertiary seal assembly 30 is then activated (as described hereinafter) so as to seal
5 against the inner surface of the casing 4.

The primary seal assembly 12 is activated in the following manner. The running tool 50 is lowered onto the bolt 60 whereby the socket fingers 70a move over the hexagonal head 62 until the dogs 71 latch into groove 68.
10 The bolt 60 is subsequently rotated in right hand direction by rotating the running tool 50, thereby compressing the elastomeric seal against the inner surface of the casing 4. Rotation is continued until the bolt 60 becomes biased against the spacer 66. Rotation is
15 then continued so that the shear pins 74 are sheared-off and the shaft 72 moves inwardly relative to the socket 70 by virtue of threaded connection 73. Upon continued rotation the tapered end part 76 contacts the socket tapers 78 thereby moving the fingers 70a radially outward
20 and unlatching the dogs 71 from the groove 68. The running tool 50 is then retrieved to surface.

After finalising the fracturing procedure, the tertiary seal assembly 30 is first retrieved, followed by retrieval of the secondary seal assembly 20 and the
25 primary seal assembly 12. Each seal assembly is retrieved in the following manner. The retrieving tool 80 is lowered through the wellbore, whereby the spool 88 is biased to its extended position by spring 100. Upon contact with the bolt 60, the nose section 94 first moves
30 towards the spool against the force of spring 98 and then pushes the spool 88 towards its retracted position against the force of the spring 100. Simultaneously the fingers 90 are rotated radially outward by virtue of their contact with the bolt 60 until the dogs 91 latch
35 into the groove 68, thereby allowing the spring

elements 93 to rotate the fingers 90 back radially inward. With the dogs 91 latched into the groove 68, the spool 88 has reached its retracted position in which the annular lock surface 89 prevents radially outward hinging
5 of the fingers 90. Torque is then applied to the shaft 84 so as to rotate the bolt 60 in left hand direction thereby deactivating the elastomeric seal 54. The seal assembly 12, 20, 30 is then retrieved to surface.

C L A I M S

1. A method of creating multiple fractures in an earth formation surrounding a wellbore formed in the earth formation, the method comprising
- 5 - sealing a first section of the wellbore from the remainder of the wellbore by arranging a primary seal assembly in the wellbore, the first section containing a first body of fluid and being located between the primary seal assembly and the wellbore bottom;
 - 10 - pressurising the first body of fluid so as to fracture the earth formation surrounding the first section;
 - sealing a second section of the wellbore from the remainder of the wellbore by arranging a secondary seal assembly in the wellbore uphole the primary seal
15 assembly, the second section containing a second body of fluid and being located between the secondary seal assembly and the primary seal assembly;
 - supporting the primary seal assembly by a first support member extending between the primary seal
20 assembly and the wellbore bottom; and
 - pressurising the second body of fluid so as to fracture the earth formation surrounding the second wellbore section.
2. The method of claim 1, wherein the first support
25 member is supported against at least one of the wellbore bottom and a body of solid particles arranged between the support member and the wellbore bottom.
3. The method of claim 2, wherein the body of solid
30 particles is selected from a body of propant particles and a body of gravel particles.

4. The method of claim 2 or 3, wherein a reaction plate is arranged between the first support member and the body of solid particles.

5. The method of any one of claims 1-4, further comprising

- sealing a third section of the wellbore from the remainder of the wellbore by arranging a tertiary seal assembly in the wellbore uphole the secondary seal assembly, the third section containing a third body of fluid and being located between the tertiary seal assembly and the secondary seal assembly;

- supporting the secondary seal assembly by a second support member extending between the secondary seal assembly and the primary seal assembly; and

- pressurising the third body of fluid so as to fracture the earth formation surrounding the second wellbore section.

6. The method of any one of claims 1-5, wherein each support member includes a support strut.

7. The method of any one of claims 1-6, wherein each seal assembly includes a cup-shaped elastomeric seal compressed between solid compression elements.

8. The method of any one of claims 1-7, wherein the wellbore is provided with at tubular element selected from a wellbore casing and a wellbore liner, and wherein each seal assembly is sealed against the inner surface of the tubular element.

9. The method substantially as described hereinbefore with reference to the accompanying drawings.

Fig.1.

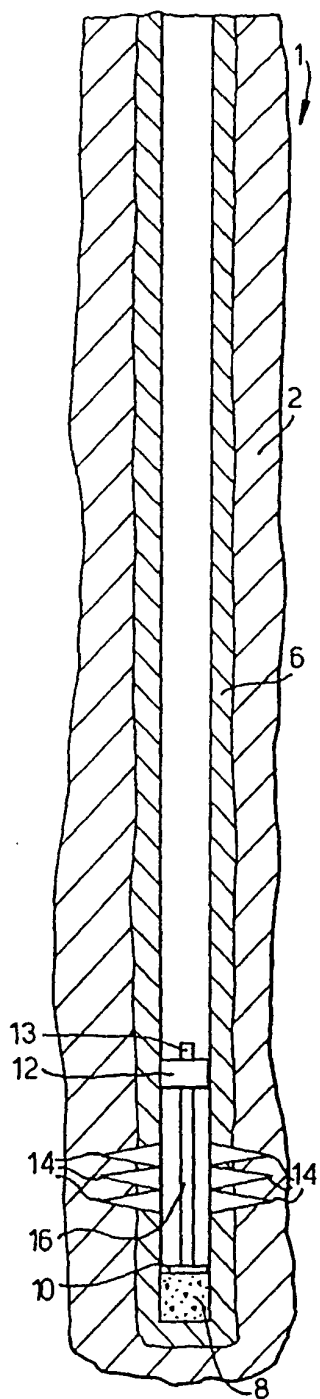


Fig.2.

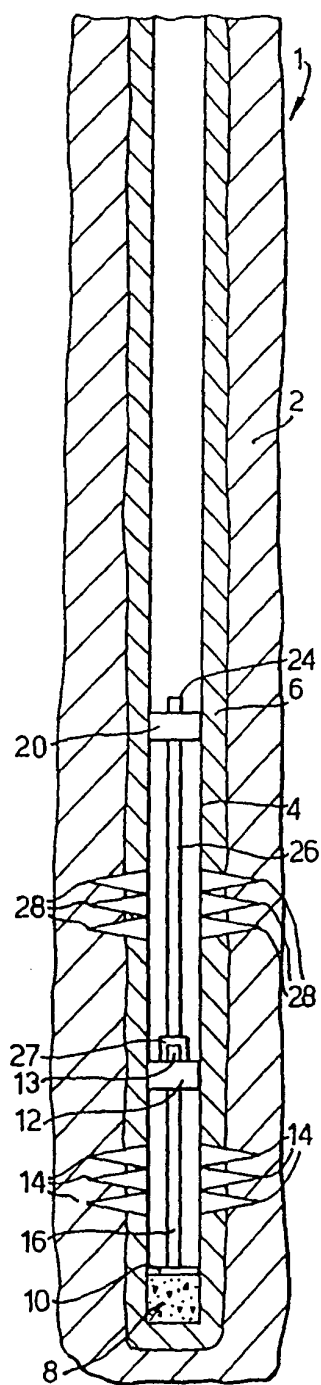
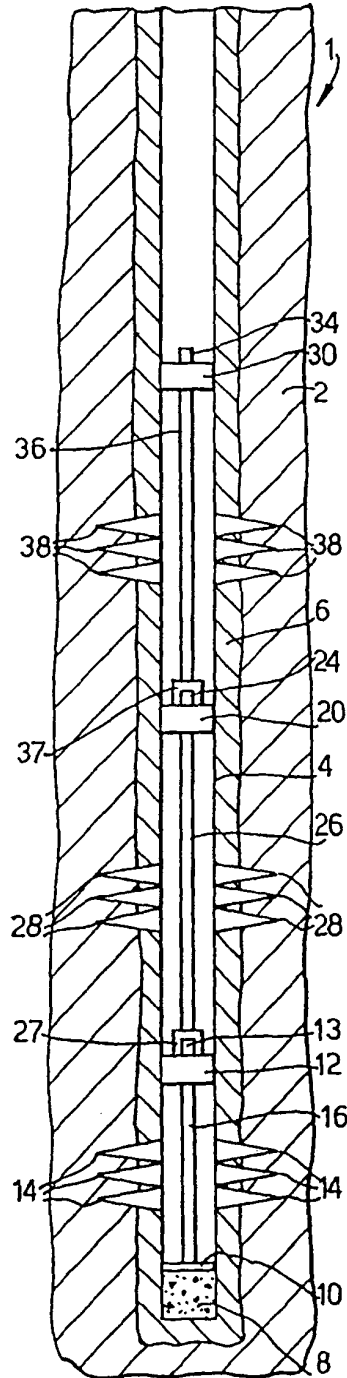


Fig.3.



INTERNATIONAL SEARCH REPORT

In national Application No

PCT/EP 00/11998

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 E21B33/124 E21B43/14 E21B43/26

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 98 19042 A (BAKER HUGHES INC) 7 May 1998 (1998-05-07) page 3, line 11 - line 26 figure 7 ---	1-9
A	US 2 927 638 A (JESSE E. HALL, SR) 8 March 1960 (1960-03-08) column 6, line 52 -column 7, line 8 ---	1-9
A	US 3 220 475 A (CLARENCE W. BRANDON) 30 November 1965 (1965-11-30) column 3, line 55 -column 4, line 44 column 10, line 19 -column 11, line 24 -----	1-9

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents:

A document defining the general state of the art which is not considered to be of particular relevance

E earlier document but published on or after the international filing date

L document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

O document referring to an oral disclosure, use, exhibition or other means

P document published prior to the international filing date but later than the priority date claimed

T later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

X document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

Y document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

S document member of the same patent family

Date of the actual completion of the international search

26 February 2001

Date of mailing of the international search report

06/03/2001

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax: (+31-70) 340-3016

Authorized officer

Garrido Garcia, M

INTERNATIONAL SEARCH REPORT

Information on patent family members

In International Application No

PCT/EP 00/11998

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9819042 A	07-05-1998	AU 5087598 A CA 2241027 A GB 2324323 A, B NO 982937 A US 6050336 A	22-05-1998 07-05-1998 21-10-1998 24-08-1998 18-04-2000
US 2927638 A	08-03-1960	NONE	
US 3220475 A	30-11-1965	NONE	